Navy Case No. 82,627

METHOD OF PRODUCING CORROSION RESISTANT METAL ALLOYS WITH IMPROVED STRENGTH AND DUCTILITY

The present invention relates generally to the formation of a metal alloy having desirable properties in addition to ductility, despite the presence of a high content of chromium therein and is a continuation-in-part of the disclosure in prior copending application Serial No. 09/233,907, now abandoned filed January 21, 1999.

BACKGROUND OF THE INVENTION

Nickel-chromium alloys with chromium contents of 40% by weight or more have extremely low ductility. An improvement in both strength and ductility by casting of such high chromium content alloys was totally unexpected.

The use of spray casting in the formation of metal alloys having a low chromium content is generally well known. Such process involves the use of an atomizing gas to which the molten alloy is exposed as disclosed for example in U.S. Patent Nos. 4,117,209, 4,606,948, 4,977,950, 5,017,250, 5,154,219, 5,489,417 and Re31,767, respectively issued to Markin et al., Hajmrle et al., Muench, Ashok, Watson et al., (2), and Brooks. U.S. Patent No. 4,779,802 to Coombs is of interest in regard to spray forming atomization. Only the foregoing referred to Markin et al. and Hajmrle patents also relate to use of the spray casting process for nickel-chromium types of alloys, expressly limited to low content chromium of 20% by weight or less. The production of Nickel-chromium alloy is also disclosed in U.S. Patent No. 5,843,587 to Nakamori for use as a gas turbine blade coating without regard to increasing alloy strength. The spray casting process was not heretofore expected to produce a metallic nickel type of alloy having the advantage of high ductility in connection with a high chromium content in excess of 40% by weight.

It is therefore an important object of the present invention to provide a method for producing a metallic alloy with a high chromium content, having an increase in both strength and ductility despite the normally expected presence of brittleness associated with high chromium content alloys.

SUMMARY OF THE INVENTION

In accordance with the present invention, a spray metal forming process is utilized to produce an alloy, wherein the alloy components are melted and mixed under cover of an inert gas and allowed to form a molten metal outflow stream that is atomized into a fine spray of molten droplets directed onto a moving or stationary surface. The alloy components are selected and exclusively limited to nickel and chromium, respectively constituting between 48% and 52% by weight of the alloy while nitrogen is selected as the inert cover gas. The referred to atomization of the outflow stream of molten metal is effected by jets of the nitrogen gas pressurized for rapid surface deposit of the molten droplets having a very fine and uniform grain structure. A ductile matrix is thereby created in the deposited alloy with a fine dispersion of brittle phases in the formation of chromium nitrides resulting from mixing of the alloy components under cover of nitrogen as a crucial selection of the inert cover gas and exposure of the molten alloy outflow stream to such nitrogen gas pressurized for atomization purposes. Improvement in ductility, as well as a boost in strength of the ductile matrix was successfully achieved as a result of the selection of nitrogen as compared to argon as the inert cover gas.

BRIEF DESCRIPTION OF DRAWING

A more complete appreciation of the invention and many of its attendant advantages will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

The drawing is a block diagram schematically illustrating the alloy forming process of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawing, the method or process of producing an alloy composed exclusively of nickel and chromium in accordance with the present invention is diagrammed. Such method involves alloy content selection 10, pursuant to the present invention, in association with a spray metal casting or forming process 12 generally known in the art. As indicated in the block diagram, alloy content selection 10 involves use of between 48% and 52% by weight as the nickel content 14 and 52% to 48% by weight as the chromium content 16. Such alloy components initially undergo heating 18, within a receptacle such as a crucible, under cover of nitrogen selected as the inert cover gas in order to melt the nickel and chromium and allow an outflow 20 of a stream of molten alloy metal from the bottom of the crucible, as part of the diagrammed spray metal forming process 12. The nitrogen gas is also pressurized as denoted by reference numeral 22 and introduced as jets into the molten metal outflow 20 so as to atomize the outflow stream and break it up into a fine spray of molten metal droplets. Such molten droplets or particles undergo deposit 24, by direction onto a rotating or stationary mandrel surface for example, resulting in billets or shapes having a very fine and uniform grain structure.

The foregoing described method was utilized to deposit fifty (50) pounds of alloy of 50% by weight of nickel and 50% by weight of chromium within a minute. The alloy so produced had a yield strength of 145 ksi and tensile elongation of 25% or greater. The exposure to the nitrogen gas during heating of the alloy content and its atomization by such nitrogen gas during the spray metal forming process 12 created a high strength ductile alloy matrix with a substantially eutectic and fine grain structure of 100 micrometers or less in average grain size as well as a uniform

microstructure. Also because of the fine chromium nitrides formed by such exposure to the atomizing nitrogen gas, a boost in alloy strength occurred.

The alloy fabrication method hereinbefore described may be beneficial in the formation of any alloy that is normally brittle due to the presence of TCP phases, by virtue of the fine dispersion of such phases within the ductile matrix.

Obviously, other modifications and variations of the present invention may be possible in light of the foregoing teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is: